China's environmental security: noncatastrophic perspective

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Offering seemingly plausible scenarios of environmentally induced socioeconomic decline, or even of a relatively sudden collapse, is not very difficult. The task is particularly easy in China's case: combination of the country's huge population, limited natural endowment and bold developmental aspirations makes the feeling that something will have to give virtually unavoidable.

Only one's imagination puts the limits on detailing grand causes and describing numerous particulars of environmentally induced destabilization in such a rapidly changing society. Perhaps the most extreme event that could affect China in the long run (but maybe as early as the first few decades of the 21st century) would be pronounced global warming resulting in a major shift of precipitation patterns. Reduced precipitation throughout already arid and semiarid northern China could desiccate the region to such an extent that mass outmigration could become the only practical solution. Changed intensity and distribution of monsoon rains in the south might have almost as profound socioeconomic effects.

Timing of such truly catastrophic events is unpredictable, and even if it could be predicted the changes themselves would remain unpreventable. In contrast, there are some anthropogenic environmental changes whose evident impacts are already causing a great deal of concern about their relatively near-term potential to seriously weaken, if not to derail, China's monumental quest for modernization. In order to assess them in some detail, I will focus on what I believe are currently the two most important environmental impacts that could imperil China's stability.

First, the greatest existential threat to the country's well-being would be posed by cumulative environmental degradation so extensive, and so severe, that it would seriously weaken the long-term capacity to feed the large, and in absolute terms still relatively fast-growing, population. This would have enormous repercussions both internally (as such a weakness would at least restrict the pace of China's modernization, and if it became entrenched it could be a source of widespread instability and a key factor leading to a profound political change) and externally (as the world grain market could find it difficult, if not impossible, to cope with a vastly increased demand, and as China would very likely become a large source of refugees).

Second, even if enough food could be produced, environmental pollution blanketing the new giant megalopolises and extending to the countryside could take an enormous toll. Initially, it would lead to rising levels of morbidity and mortality (both trends are already well documented in a number of Chinese cities). Eventually, it could cause acute air pollution episodes that could see large numbers of people dying prematurely and China's average life expectancy declining steadily. Or, summing up the two scenarios bluntly, could China's anthropogenic environmental changes lead to catastrophes due to starvation or pollution—or both?

I will assess each of these possibilities by describing the conditions now prevailing in China, by setting them into appropriate historical perspectives and comparing them with changes in other nations, and by looking at the extent of possible future deterioration and outlining some basic options for preempting, or at least moderating, undesirable shifts.

China's food production capacity

China of the late 1990s is a country enjoying unprecedented level of nutritional supply, in both quantitative and qualitative terms. Average per capita food availability is now over 2700 kilocalories (kcal) a day, nearly 15% above the Indian mean and only some 5% behind the Japanese rate.

The United Nations Food and Agriculture Organization, an institution prone to see food shortages rather than to point out comfortable supplies, concludes that this rate equals about 112% of food energy actually needed to cover the requirements of healthy and active life (FAO 1966). My calculations show that the food safety margin may be actually a bit larger, closer to 20% in 1995. Obviously, only a string of extraordinary natural catastrophes or a spell of monstrous mismanagement could alter this relatively comfortable situation in the short run.

This fairly comfortable position has been further strengthened by substantial qualitative improvements of average nutritional intakes. Official figures indicate that between 1980 and 1995 average annual per capita consumption of red meat almost tripled (to 35 kilograms [kg]), poultry supply (now at 7 kg) grew nearly ninefold, harvests of aquatic products (in 1995 just over 20 kg of mostly freshwater fish) rose about sixfold, and in 1995 Chinese ate six times as many eggs (about 14 kg) as 15 years ago. During the same period the retail supply of plant oils doubled (to almost 5 kg), that of sugar nearly doubled (to 7 kg), and consumption of liquors grew more than fourfold (to 15 kg).

Even when conservatively estimated, China's average per capita intake of animal foods is at least 20% higher than the global average. Given at least a modicum of sensible management, this relatively comfortable situation cannot deteriorate rapidly. Clearly, China's current meat and egg intake represents a substantial grain reserve that could be tapped in times of a food crisis.

Reducing animal food intake would not be welcome by Chinese consumers eager to buy more of these foodstuffs—but it would present no nutritional hardship as healthy diets resulting in low infant mortalities, low morbidities, active life, and long life expectancies are quite compatible with even much lower levels of animal food consumption.

But reducing the annual per capita demand of animal foods from about 40 to just 20 kg would release land currently devoted to feed production that could yield at least 60 million metric tons (t) of food grain. This mass is about three times as large as China's record grain imports in 1995. Faced with either shortages of grain on the world market or with too high a price of food imports, China clearly could, within a year, produce enough food grain to ride out any short-term crises.

Seen in a longer perspective, 60 million t of grain would be also sufficient to supply staple cereals for at least 200 million people at the current level of average food intakes. That population total is equal to the cumulative increase anticipated during the next 15-17 years. Again, this shows that even if China is unable to raise its food productivity (an unrealistic assumption indeed!) it could avoid any acute food crisis during the next 10-15 years by adjusting the food/feed grain ratio, a shift many societies undertook during times of crises.

I will argue that—with the exception of a climate change of unprecedented rapidity and extent—no plausible combination of environmental problems can fundamentally reverse this relatively comfortable situation in the short run (5-10 years), and China's food output can continue growing throughout the next 20-25 years.

These conclusions can be made because none of the five most important degradative processes affecting crop production—natural catastrophes, loss of farmland, declining soil quality, lowered water availability, and higher levels of pollution—has reached a stage where yield declines are inevitable, and because a combination of already available, and steadily improving, management options can moderate, neutralize, or eliminate virtually all undesirable environmental changes.

Natural catastrophes would have to be of unprecedented magnitude to change this outlook. Floods and droughts that cause some reduction of normal crop yields affect between 15 to 25 million hectares (ha) of the country's farmland every year (or as much as one-fifth of all cropped land), but these recurrent disasters have not prevented a steady rise in overall production (State Statistical Bureau 1995). Indeed, the 1995 record harvest of 466 Mt of grain was achieved in spite of extensive summer flooding, and another record harvest was brought in in 1996 in spite of the Yangzi basin floods that rank among the worst during the past two generations (Crook 1996).

China's farmland is not limited to 95 million ha officially claimed by the State Statistical Bureau: the real figure is between 120 and 150 million ha, which means that the country's 1995 per capita arable land availability is at least at, or slightly above, 0.1 ha (Smil 1993; Crook 1993; Wang et al. 1992). This rate is no less than 2.5 times as high as in Japan or Taiwan, and twice as large as in South Korea (USDA 1996). Clearly, China is not as land-short as these two nations with which its future food supply situation is so commonly compared.

This reality also means that most of China's official crop yield figures are wrong. Prorating the officially reported harvests over larger areas of farmland would make the smallest difference for rice yields (as paddy land is not widely under-reported) and the largest difference for corn which may be grown in some provinces on areas 20-40% larger than officially acknowledged. China has thus considerably more room to improve the yields of this key feed grain (Crook and Colby 1996).

Even when assuming that the recent high net rate of farmland losses, averaging around 500,000 ha a year, would continue during the next generation, the country would still have at least around 110 million ha of farmland by the year 2020. Combined with a high population projection of 1.5 billion people this would give China per capita availability of 0.07 ha, just slightly worse than the official 1995 mean, and still almost twice as much as today's Japan.

Even with the total area unchanged, severe qualitative deterioration could appreciably diminish the extent of farmland capable of producing high yields. Undoubtedly, China's soil erosion and salinization have been excessive in a number of regions, the former mainly throughout the north and the northwest, the latter above all in Jiangsu, Anhui, Shandong, and Hebei. Recent retreat from cultivation of green manures and declining amounts of organic wastes in periurban regions (due to a widespread construction of urban sewers) have contributed to the lowering of organic matter content in some soils.

But these changes are not harbingers of imminent production decline. We have come to realize that declines in soil quality—difficult to quantify in the first place, mainly because of a limited amount of historically comparable information—have usually produced only gradual, and marginal, effects on yields, and that they can be controlled, and reversed, by appropriate agronomic practices even in the most vulnerable areas (Crosson and Anderson 1992).

Indeed, a recent comparative study of China's soil quality does not show any worrisome large-scale decline between the 1940s and the 1980s (Lindert 1996). Similarly, an evaluation of environmental degradation on cereal crop yields indicates a noticeable, but a fairly marginal loss amounting to about 6 million t a year during the late 1980s, and equivalent of less than 1.5% of annual grain harvest (Huang and Rozelle 1995).

China's water shortages, above all throughout the North China Plain and in the arid north and northwest, have been widely reported in local and national press, and linear extrapolations of demand foresee some very serious bottlenecks developing within a decade or two. While the current shortages are real, the reasons for them must be ascribed primarily to China's irrational management of water rather than to the rapidly approaching limits on actual water withdrawals.

China of the 1990s is withdrawing its available water at a lower percentage rate than India, but it has been doing so in an extraordinarily wasteful manner. Irrigated crops with high water requirements are often grown in inappropriate settings (there is surely no need to grow rice in Beijing's suburbs), typical irrigation techniques have low field efficiencies (often below 30%), and water is available to farmers at a small fraction (as low as one-tenth) of its actual cost.

Urban and industrial waste water treatment and recycling are highly inadequate (nationwide less than a quarter of industrial wastewater is treated to reach acceptable standards). Gradual improvement of these deficiencies holds considerable promise for increasing effective water supply throughout semiarid and arid northern provinces even without resorting to any massive south-north water transfers.

Considerable Western experience with effects of classical smog, arising from combination of sulfur dioxide (SO_2) and suspended particulate matter, on crop yields shows only a limited damage whose impacts is usually masked by rising productivity (NAPAP 1991). Recent assessments for China echo those realities. Total damages caused to China's crops by air pollution have been estimated at between 2 to 7 billion yuan a year (Smil 1996; Xia 1996). While locally crippling, and regionally important, these damages represent only about 1% of the total value of crops produced annually in the country during the early 1990s.

At the same time, some pollutants have actually a beneficial impact. Switching to ammonia and urea from previously common ammonium sulfates led to growing sulfur deficiencies, especially in soils producing such high-protein crops as soybeans; signs of the same problem have been also noted in China, and atmospheric sulfate deposition helps to moderate that shortage.

Photochemical smog, with its high levels of ozone, an aggressive oxidant harmful to many plant tissues, appears to be a more serious matter. Depending on the assumed level of natural ozone concentrations, annual economic effects of ozone pollution on eight sensitive U.S. crops was put at roughly $1-3 billion a year during the late 1980s, or as much as 6% of the total harvested value (NAPAP 1991). In spite of some high local ozone levels and spreading extent of photochemical smog, both the typical concentrations and affected areas in China are still below the U.S. rates. As tropospheric ozone levels rise throughout China, so will the damage to sensitive crops.

Obviously, none of these damages are going to triple or quintuple within the next few years; even without any air pollution controls they would rise along with higher emissions, growing no more than 5-8% a year; that is, doubling in 9-14 years.

At this point, I hasten to add that I am not dismissing either the continuing loss of China's cropland or problems with its quality, and that I am not trying to trivialize current damages due to air pollution (those caused by water pollution have been estimated to be much lower than for smog). I am merely pointing out the actual current state of affairs and realistically projecting the impacts of further deterioration. As with any ecological assessment, time spans make the critical difference.

Given just a modicum of sensible management, environmental changes affecting China's food production cannot seriously weaken the country's capacity to feed itself during the next 5-10 years. Adequate investment in agricultural research, a rising quality of farm inputs, and higher efficiency of field production and animal feeding—measures not calling for any revolutionary advances but demanding sustained attention—would help to assure that the outlook for the following 10-15 years could continue to be fairly comfortable.

In contrast, relative neglect of agricultural sector and a slow progress in remedying such critical environmental factors as shortages of irrigation water (a more realistic pricing could be of immense help) or rising levels of photochemical smog (impossible without better transportation policies) could mean that the second decade of the next century could be a period of rising concerns about China's long-term capacity to feed itself.

Intolerable environmental pollution

I will illustrate the realities and the options within this wide-ranging category of problems by focusing on the most obvious form of China's pollution, the dismal quality of its urban air. Genesis of this problem is in China's extraordinarily high dependence on coal: for decades that fuel has supplied more than 70% of all primary energy consumption, a share now unparalleled in any other nation. Moreover, the post-1980 economic expansion made China both the world's largest producer and consumer of coal.

Most of the fuel is still burned without any previous cleaning in relatively inefficient medium- and small-sized boilers and in tens of millions of household coal stoves. Inevitably, emissions of total suspended particulates (TSP) and sulfur dioxide have gone up. Official statistics put TSP emissions at about 15 million t (State Statistical Bureau 1995). According to the same source, SO_2 releases rose from some 12 million t in 1980 to about 19 million t in 1995, but some prominent Chinese atmospheric scientists believe that the total may be up to 15% higher.

Concentrations of these pollutants in China's large cities frequently surpass the nation's hygienic norms, with peaks being an order of magnitude above the permissible limits. China's ambient air quality standards set the allowable annual average of SO_2 at no more than 60 micrograms of SO_2 per cubic meter of air (60 $\mu g/m^3$), and the highest 24-hour concentration at 150 $\mu g/m^3$, requirements stricter than in the United States, where the two values are, respectively, 80 and 365 $\mu g/m^3$.

Not surprisingly, these maxima are commonly exceeded in all of China's large urban areas. Even Beijing's cleanest residential areas average between 80-100 $\mu g/m^3$, mean annual levels in the most polluted northern cities are commonly twice the allowable level, daily maxima are often above 300 $\mu g/m^3$, and short-term winter peaks go above one $\mu g/m^3$ (Smil 1996).

In contrast, today's mean SO_2 levels in North American cities are commonly below 20 $\mu g/m^3$, and even the Tokyo megalopolis averages just 30 $\mu g/m^3$ (U.S. Department of Commerce 1995; Environment Agency 1995). But while Chinese ground concentrations are considerably higher than in any affluent country, they are very much like the levels that were common in most urban and industrial areas of rich nations as recently as the mid-1960s.

At that time Japanese mean of SO_2 in urban areas was 150 $\mu g/m^3$, and concentrations above 100 $\mu g/m^3$ were not unusual in large cities of America's Midwest and Northeast. And these high levels had prevailed during winter months in parts of central Europe even during the 1980s, and in some locales still in the early 1990s.

China's total SO_2 emissions and their density are not unprecedented either. Total U.S. SO_2 emissions of about 19.5 million t in 1995 are still about as large as China's total, which means that in per capita terms they are at least 4.5 times larger. Emission density provides a more environmentally meaningful comparison: American SO_2 emissions in states with the highest concentration of large coal-fired power plants (Ohio, Pennsylvania, Kentucky, Tennessee) average between 10-20 t SO_2/km^2, and the highest European national means are very similar. In contrast, during the first half of the 1990s Chinese SO_2 emissions in the largest coal-burning provinces of north and east China (Liaoning, Hebei, Henan, Shanxi, Shandong, and Jiangsu) prorated to between 5-9 t SO_2/km^2 (Smil 1993; Smil 1996).

Two reasons explain why North American and European ground-level concentrations are not as high as in China: most SO_2 emissions are released from tall stacks of large power plants and their mixing into large volume of the lower troposphere reduce the ground concentrations; in the United States more than half of large coal-fired power plants are equipped with flue gas desulfurization.

But just 30-40 years ago the Western short-term maxima encountered during unfavorable weather conditions had repeatedly reached levels that resulted in significant increases of excess mortality. During the episode of heavy air pollution in London in early December 1952 average levels of SO_2 stayed above 1000 $\mu g/m^3$ for four consecutive days (Brimblecombe 1987). And during the Thanksgiving 1966 episode in the eastern United States, the highest daily mean of SO_2 in New York surpassed 1300 $\mu g/m^3$, and concentrations of the gas remained above 500 $\mu g/m^3$ for six consecutive days (Fennsterstock and Fankhauser 1968).

Such exceptional air pollution episodes were associated with temporarily increased mortality among the most vulnerable groups of exposed populations (above all elderly people with respiratory and cardiovascular ailments): London smog of December 1952 was credited with some 4000 premature deaths. Cleaner fuels and air pollution controls prevented further occurrence of such high air pollution episodes, and the subsequent chronic exposures to lower concentrations of SO_2 and TSP have much more subtle effects that have not been easy to quantify.

Decades of intensive research interest into the effects of SO_2 and TSP on human health have found significant statistical relationships with higher frequency of upper respiratory infections, with increased incidence of chronic obstructive lung diseases (bronchitis, asthma) and with lung cancer. Chronic exposures to relatively high levels of urban air pollution have thus obviously contributed to the changing patterns of morbidity and mortality—but they could not prevent the continuing rise of life expectancy throughout the rich world.

The very same experience is being repeated in China. As expected, we are seeing higher incidence of chronic obstructive pulmonary diseases (they now account for about a quarter of all deaths, and their rate is at least four times higher than in the United States). But correlating these changes to outdoor air pollution is complicated by China's extraordinarily high rates of smoking and by often very high levels of indoor air pollution from improperly vented stoves. Indeed, this latter factor may be as large, or even a larger, contributing factor (Smith and Liu 1994).

In any case, Chinese life expectancy has shown a steadily, and impressively, rising trend, increasing from less than 60 years in the mid-1960s to just over 70 years in 1995, with two additional years added since the beginning of Deng's reforms in 1980 (State Statistical Bureau 1995; United Nations 1995). Declines in infant mortality have accounted for most of this gain: health impact of worsening pollution problems should be felt first among the most sensitive groups of the affected population—but China's infant mortality fell by nearly a third between 1980 and 1995, to just below 30, giving the country a lower rate than the mean for the world's middle income nations (United Nations 1995).

Clearly, it is difficult to argue on the basis of this evidence that air pollution is undermining the well-being of China's population to such an extent that it could soon lead to massive health crises whose impact could become a notable destabilizing factor in the country's developmental aspirations. At the same time it must be appreciated that the Chinese are already doing more about the problem than the affluent nations had done at a comparable stage during their modernization.

Exploring this evolution using official exchange rates is not appropriate because they are highly misleading. Indeed, even the preferable assessments in terms of the purchasing power parity (PPP) remain just good approximations rather than accurate valuations. There is now a growing consensus, for example, that the earlier PPP calculations, putting China's per capita gross domestic product (GDP) at close to $3000 in the early 1990s, were exaggerations, and that China's 1995 per capita GDP did not surpass $2000 (World Bank 1996).

Yet nearly a decade ago this still decidedly low-income society had established a National Environmental Protection Agency (NEPA). It has adopted a variety of environmental quality standards and it has set up a system for enforcing its new anti-pollution regulations. Not surprisingly, NEPA is underfunded, most standards are commonly violated, and enforcement is haphazard at best.

At the same time, one must remember that rich countries began to pay serious attention to environmental degradation in general, and to air pollution in particular, only when their per capita GDPs were considerably higher than in China of the early

1990s. Britain enacted its first anti-air pollution law in 1955, and the United States only in 1971, when the country's per capita GDP was over $18,000 (in 1995 dollars).

Even more fundamentally, China has been increasing its overall energy-use efficiency faster than any other nation during a comparable stage of its modernization (Smil 1993). Long-term declines in primary energy consumption per unit of GDP have been impressive throughout the Western world during the 20th century—but the recent Chinese improvements have been even faster.

China's mean energy intensity was about 0.7 kilograms of coal equivalent (kgce) per constant (1980) yuan of GDP; by 1990 the rate declined to 0.42 kgce/yuan, and in 1995 it was slightly below 0.35 kgce/yuan, or a bit less than half the value 15 years ago. Consequently, if China's energy/GDP ratio were to remain at the 1980 level, the country's 1995 primary energy use would have been twice as large, and because the structure of primary energy use has changed so little, the resulting emissions would have grown by the same factor.

Further reductions of China's SO_2 and TSP air pollution will come as the country's fuel consumption gets transformed according to a universal pattern of primary energy use. A rising share of bituminous coal is burnt in large, modern electricity-generating stations, where efficient electrostatic precipitators remove more than 98% of all fly ash, and where SO_2 emissions are scrubbed and/or dispersed from tall stacks higher into the troposphere and transported over longer distances, preventing a build-up of excessive ground-level concentrations.

Of course, once oxidized, these SO_2 emissions become the principal ingredient of acidifying deposition, but dry north China, where most of the new large coal-fired plants will be located, has a naturally high levels of airborne alkaline cations in dust whose presence can keep the pH of the region's rain above the level harmful to most biota. Rainy south China, whose coals also have higher sulfur content, does not enjoy that advantage, and further expansion of the area affected by acid precipitation south of the Yangzi is thus inevitable.

We have a great deal of European and North American experience with this phenomenon, and thus can reasonably conclude that acid deposition would be a most unlikely source of environmental degradation leading to socioeconomic destabilization. While potentially costly—above all in terms of its impact on materials, and on sensitive waters and biota—acid deposition is a manageable environmental deterioration, whose effects can be moderated, and eventually reversed, with a combination of liming, flue gas desulfurization and switching to cleaner fuels. Undoubtedly, during the next generation China will be moving, albeit slowly, in all of these directions.

In addition to SO_2-TSP pollution, recent rapid multiplication of passenger cars and trucks, and growing emissions of thermal NO_x from large power plants, have been responsible for no less objectionable and potentially no less damaging episodes of heavy photochemical (Los Angeles-type) smog. Our experience clearly shows that as long as car ownership and electricity generation expands rapidly, this form of pollution is much more difficult to control.

However, as already noted, effects of photochemical smog on crop yields will remain in the realm of regrettable marginal losses, rather than in the category of drastic reductions. And the experience with high NO_x and O_3 levels in the modernizing world's megacities—ranging from Cairo and Tehran in the Middle East to Bangkok and

Taipei in Asia—demonstrates that photochemical is a highly objectionable form of pollution, obviously harmful to many sensitive individuals, but, in the final benefit-cost analysis, a condition tolerated by millions of urban dwellers unwilling to give up their cars—and hence hardly a matter of imminent socioeconomic destabilization.

Realities and concerns

China, much as any other large and rapidly modernizing nation, is already paying a substantial price for its serious environmental degradation. Increasing attention to these changes—most notably, the total investment in environmental protection in the year 2000 is to be double the 1995 sum—will bring some improvements, but the combination of continuing population and economic growth makes it almost certain that the overall state of China's environment is not going to improve radically during the coming generation. But these costly, and individually painful, or even crippling, realities must be seen in proper historical perspective, and they must be weighed against further improvements in the overall quality of life.

Viewed in these contexts, there is little doubt that China's environmental degradation will continue to be an economic burden and a social aggravation but that, taken alone, it will not derail the country from its path of modernization, nor will it precipitate any worrisome destabilization of Chinese society during the next ten to twenty years.

When looking beyond that time horizon it is much easier to make a case for more serious concern about the state of China's environment—but also for unpredictable changes that may fundamentally alter today's speculations. After all, 25 years ago even the most astute China watchers could not have predicted any of the key features of today's China. At that time the country was still in the midst of Maoist madness, cruelly mislabeled as the Cultural Revolution; it was merely a decade since the end of history's greatest man-made famine that claimed 30 million lives; all food was rationed at levels no better than 15-20 years earlier; economically, the country was an isolated, Stalinist autarchy; there were no Chinese students abroad, and no foreign investors inside.

Today's contrasts with those quarter-century old realities are truly astonishing. Changes that took place since the early 1970s obviously contributed to further degradation of China's environment—but, for the first time in the country's long history, they also laid foundations for decent quality of life for most of its people. And the historical experience demonstrates that only after reaching that developmental stage will a nation turn more of its attention to the state of its environment and embark on a difficult quest of reconciling human well-being with the preservation of biospheric integrity.

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